

Collimation Measurements General Considerations - Surface measurements on concrete dams consist of two major types: (1) those that use monuments and markers or targets to measure movements of the dam from a remote point, and (2) those that are mounted on the exterior or interior surfaces of the dam from which differential movements of portions of the structure are determined, including measurements of joints and cracks. The devices are used to measure total or relative horizontal, vertical, or rotational movements or differential movements in any desired plane. Collimation is (tangent-line measurements) is an example of monuments and markers measurements.

Collimation is a means for determining the deformation of a concrete dam with respect to references located off the dam. The bending, tilting, or horizontal displacement of a concrete dam may usually be detected by accurately measuring changes in the horizontal position of the various portions of the dam. Measurements of the location of the dam monoliths at regular intervals of time over several years provide an indication of the magnitude of deformation that occurs in the structure, its foundation, and abutments.

Alignment observations supplement plumbline deflection measurements and the theoretical load analysis in determining the relative magnitude of the horizontal displacements resulting from structural deflection or foundation deformation. These data are valuable as indication of stability of the structure and also furnish information regarding the accuracy and validity of the various design assumptions and analysis procedures. This method provides information on the magnitude and direction of movements of a dam with reference to the dam's surrounding, not merely relative movement of points on the dam. The surveying methods used is relatively common techniques; however, they must be performed to a high degree of accuracy to provide meaningful information. Instrument piers and target located off the dam must be constructed so that they will not move and thereby destroy the accuracy of the measurements on the dam. The instruments and devices used for collimation measurements include theodolites, stationary instrument piers, moveable and fixed targets, moveable and fixed targets, and embedded markers or plugs. Pier details are show on drawing 40-D-5822 fixed targets are shown on drawings 1054-D-85, 40-D-5998, and a non-numbered drawing, while movable targets are shown on drawing 40-D-6128.

All survey readings are taken with highly precise surveying equipment. Care should be taken to achieve precise and accurate data when using theodolite equipment. Instrument piers and targets are located on one of the abutments at a concrete dam, usually the one that has the easiest access for the pier and instrument setup, and should be founded on solid rock when possible. Details of a typical pier installation are shown on drawing 40-D-5998. Depending on curvature of an arch dam and the number of targets to be monitored on the crest, more than one pier may be required. On the opposite abutment, sighting targets are installed at as many locations required to accommodate the moveable targets located at the measurement points on the dam. These sighting targets are installed in 1.5-inch diameter pipes that have been solidly cemented into holes frilled into the abutment as shown on drawing 40-D-85 or figure 1. The points on the dam are either installed using movable target systems or fix targets. The movable targets, with fit on plates affixed to the dam are shown on drawing 40-D-6128. The plates used are common to both the piers and the dam targets. The three 120° V-slots in the anchor plate ensure correct alignment of the movable target and the theodolite placement on the pier. The fixed target on the

dam uses saw tooth target attach to a pipe installed into the concrete of the dam. The saw tooth is very close to the saw tooth on the fixed abutment target shown on drawing 40-D-5998.

Taking of collimation readings - Measurements must consistently be taken from the same fixed target and pier to the moveable wheel target or fixed target on the dam. It is very important that the same line of sight from the abutment pier or piers to the abutment target or targets be used and extended to each target location on the dam. When setting up the moveable target wheel on the fixed plate located on the dam, all surfaces must be clean and the target wheel be aligned in the three grooves of the plate at the same position each time and it is always faced to the pier where the measurements are to be taken every time. A mark should be used on the movable wheel target to aid in this setup. The black background plate should be mounted on the movable wheel assembly and used on all measurements (see drawing 40-D-6128). This background plate will aid in the sighting of the center point of the wheel when making the alignment measurements.

At one dam, readings are performed the first week of each month, in the required quarter that the readings are due. The April and October readings are taken at 0700 hours, and the July readings are performed at 0600 hours. The early morning readings reduce the amount of heat waves given off by the sunlight and the warming of the dam. However, heat waves are still present due to the temperature differences between the warm concrete and the cool ambient air temperatures. While looking through the theodolite at the back site target or the measurement sites, the sites tend to float back and forth from the theodolites' center line. An average of this floating is used to determine the reading. At this dam site this only occurs on the left side of the dam (the farthest from the theodolite pier) as you get closer to the theodolite the readings have far less heat waves resulting in a smaller amounts of deviation. The instruments are stored inside the dam and taken outside so they will tend to become more closely related to the outside morning temperatures.

The measuring equipment is taken to the top of the dam and the theodolite is set up onto the abutment pier's base. The equipment is given approximately 30 minutes to stabilize to the outside temperature. During this time the theodolite is leveled on the base of pier and aligned or centered to the opposite abutments back site target. Meanwhile the embedded plates for the movable wheel are cleaned. Readings are taken starting from the west abutment at Block 6. The measuring wheel is placed into the proper position on the embedded plate and brought to a random position upstream of the present alignment line of site. The Observer radio's the person who is the Recorder to move the wheel downstream until the site line is centered of the cross hairs in the theodolite on the middle of the wheel. The wheel is moved in the same direction for all measurements so that any slack in the screw of the wheel will always be accounted for. The measurements of the movements are taken by using a caliper that measures the distance between the knurl nut's edge of the collimation wheel to the shaft support of the collimation screw. Using the caliper, the Recorder makes this measurement on the downstream side of the wheel and records it. The Recorder then positions the wheel randomly upstream (approximately ½-inch) and the process is repeated of bringing the wheel downstream until it is centered again. This process is repeated if necessary until two readings are recorded within 0.1-inch. The readings are then compared with the previous readings to see if there are any major discrepancies. This

process is continued across the dam while verifying that the theodolite remains centered on the back site.

Once all measurements are completed the covers are reinstalled over each of the embedded plates in the crest of the dam. The theodolite is removed from the pier and stored once again in the powerplant after each use. Calculations are performed on the readings to compensate for instrument design and then faxed to the area office. The embedded plate covers get sealed after the October readings and remain sealed through the winter until the first readings for the year are taken in April.

Maintenance of collimation equipment Maintenance of collimation equipment involves keeping the measurement points, targets, and plates clear and visible from the necessary reference lines and points. Normal maintenance of the surveying equipment is required, oiling, and cleaning the optics. Clean the external surfaces of lenses with a fine brush and, if necessary, use a dry lens tissue. Do not use silicone treated tissues, as they can damage the coated optics. You can breathe on the lenses before wiping it, but liquids, such as oil, benzene, water, etc. should never be used for cleaning. Cover an instrument whenever it is uncased and not being used for any length of time, particularly if there is dust, moisture, and sunny light on the instrument.

Data Processing and Review All field data forms should be transmitted to your Area Office or to the TSC in Denver. Once the data has been received it is reviewed and evaluated.